POLAR HYDRA Data Analysis

Annual Performance Report

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4/1/97 – 3/31/98

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NAG 5-2231

1) Hydra is still operating successfully on orbit.

2) A large amount of analysis and discovery has occurred with the Hydra ground data processing this past year:

3) Full interdetector calibration has been implemented and documented. This intercalibration was necessitated by the incorrect installation of bias resistors in the pre-acceleration stage to the electron channeltrons. This had the effect of making the counting efficiency for electrons energy dependent as well as channeltron specific. The nature of the error had no impact on the ion detection efficiency since they have a different bias arrangement. This intercalibration is so effective, that the electron and ion moment densities are routinely produced with a level of agreement better than 20%.

4) The data processing routinely removes glint in the sensors and produces public energy time spectrograms on the web overnight. These can be viewed from http:www-st.physics.uiowa.edu.

5) Key Parameters are available and delivered to NSDC for data through June 1997.

6) Routine, but more intensive computer processing codes are operational that determine for electrons and ions, the density, the flow vector, the pressure tensor and the heat flux by numerical integration. These codes use the magnetic field to sustain the quality of their output. To gain access to this high quality magnetic field within our data stream we have monitored Russell's web page for zero levels and timing files (since his data acquisition is not telemetry synchronous) and have a local reconstruction of B for our use. We have also detected a routine anomaly in the magnetometer data stream that we have documented to Chris Russell and developed an editing algorithm to intercept these "hits" and remove them from the geophysical analysis.

7) Enroute to the above, it has been imperative to use the best information of the spacecraft potential. We have had the assistance and access to the estimates of the S/C floating potential from Forrest Mozer. Unfortunately these estimates are not always available, particularly in the cusp region when his sensor goes into oscillation. We have worked with him to characterize the spacecraft return current floating potential relationship WHEN the floating potential measurement is judged by Mozer to be a viable measurement. As this relationship is a property of the S/C surface interaction, we can parameterize this relationship and use it to find the potential when EFI is in oscillation. This relationship uses, and corrects for secondary production. This relationship is used for all production processing including key parameter production.

8) During this period active subcontracts to Northwest Enterprises (Whipple), UNH, UCSD, and LANL have been funded. After a particularly difficult period with UCSD it has been decided that those funds were not being well used and that grant has been terminated. At the same time Reiner Friedel, a co-I from Germany, has taken up a job at the LANL and requires direct US support. I have redirected funds toward LANL from the terminated UCSD subcontract.

9) Science activities by institutions are available and routinely updated on web address:
http://www-st.physics.uiowa.edu/www/html/hydra_science_pres_pub.html

10) During this period we have been testing our burst-mode in which we acquire data 4 times faster than normal, using either our own internal trigger or that of the EFI team. This is now operational and primarily being used in the auroral region.

11) Our PPA subsystem is working well. The anomaly of the magnetic field time series, mentioned above, that we use onboard to sort electrons by pitch angle, is severely compromising its interpretation, since the nature of the defect is to tell the data stream that the magnetic field is rapidly first aligned with the spacecraft spin vector and then recovers to the true geophysical direction near the spin plane with a damping constant that is 20-25 sample into the PPA measurement stream. This defect occurs every minute or so, breaking PPA energy spectrum in ways that have yet to be fully unraveled.

12) During this last year HYDRA team members Reiner Friedel, Jack Scudder and Jeremy Faden have engineered a major advance in data evaluation that has yet to reach its fullest maturity: PAPCO. PAPCO is a Panel Plotting Composer, that allows the simultaneous display and access to multiple instrument data sets, without the people interface in between. Currently all Polar instruments are incorporated and soon Geotail data and some Wind data will be available for correlative study. Also key parameters are also available through this vehicle.

Major discoveries with Hydra:

1) Physics of the bar in the Theta Aurora as imprints of motion of merging line.
2) First corroboration of the detection of significant E_{parallel} on auroral field lines.
3) First documentation of traversal of reconnection layer and diffusion region of reconnection. In situ rather than indirect proof of reconnection in the for B_z northward in the cusp region. Indicators that electron pressure anisotropy and departures from gyrotropy are the causes for frozen flux violation in the reconnecting layer.

Submitted with Annual Performance Report
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UIowa Polar/HYDRA Papers

- **Submitted Papers**
- **Accepted Papers**
- **Published Papers**
- **Online Papers**

UIowa Hydra/Polar Submitted Papers

- **Observations of traveling Pc5 waves and their relation to the magnetic cloud event of January, 1997**, J. H. Clemmons, R. P. Pfaff, O. W. Lennartsson, F. S. Mozer, H. J. Singer, W. K. Peterson, J. D. Scudder, C. A. Kletzing, P. Chi, D. D. Wallis, and D. E. Larson,submitted to J. Geophys. Res., Jan. 1998.
- **Direct Observation of large quasi-static, parallel electric fields in the auroral acceleration region**, F. S. Mozer and C. A. Kletzing, submitted to Geophys. Res. Lett., Dec. 1997.
- **Comparison of Auroral X-ray Emissions with Simultaneously Measured Energetic Electron Precipitation**, P. C. Anderson, D. Chenette, J. M. Quinn, and M. Grande, and M. Walt (Other co-authors?), submitted to Geophys. Res. Lett.
- **Interaction of the Solar Wind and the Magnetosphere during Quiet Times - the Theta Aurora**, S.W. Chang, W.J. Burke, N.C. Maynard and J.D. Scudder, contributed article submitted to EOS, 1997.
- **Modelling signatures of pulsed magnetopause reconnection in cusp ion dispersion signatures seen at middle altitudes**, M. Lockwood, C.J. Davis, T.G. Onsager, J.D. Scudder, submitted GRL, November 1997

UIowa Polar/Hydra Accepted Papers

- **A Comparison of a Model for the Theta Aurora With Observations From Polar, Wind, and SuperDARN**, S.-W. Chang, J. D. Scudder, J. B. Sigwarth, L. A. Frank, N. C. Maynard, W. J. Burke, W. K. Peterson, E. G. Shelley, R. Friedel, J. B. Blake, R. A. Greenwald, R. P. Lepping, G. J. Sofko, J.-P. Villain, and M. Lester, *J. Geophys. Res.*, in press, 1997

- **Dayside Electrodynamics Observed by Polar with northward IMF**, N.C. Maynard, W.J. Burke, D.R. Weimer, F.S. Mozer, J.D. Scudder, C.T. Russell, and W.K. Peterson, Huntsville meeting procedings, February, 1996, AGU Monograph

- **Near Earth Plasma Sheet Penetration and Geomagnetic Disturbances**, L.R. Lyons, G.T. Blanchard, J.C. Sampson, J.M. Ruohoniemi, R.A. Greenwald, G.D. Reeves, and J.D. Scudder, accepted AGU Monograph: New Perspectives in the Earth's Magnetotail, January 1997.

- **Relationship of topside ionospheric ion outflows to auroral forms and precipitation, plasma waves, and convection observed by Polar**, M. Hirahara, J.L. Horowitz, T.E. Moore, G.A Germany, J.F. Spann, W. K. Peterson, E.G. Shelley, M. O. Chandler, B. Giles, P.D. Craven, C.J. Pollock, D.A Gurnett, J.S. Pickett, A.M. Persoon, J.D. Scudder, N.C. Maynard, F.S. Mozer, M.J. Brittnacher, and T. Nagai, in press JGR, 1997.

- **Polar observations of cusp electrodynamics: evolution from 2- to 4- cell convection patterns**, N.C. Maynard, W.J. Burke, D.R. Weimer, F.S. Mozer, J.D. Scudder, W.K. Peterson, R.P. Lepping, and C.T. Russell, proceedings of the Svalbard meeting, 1997.

- **Field and Flow Perturbation in the October 18-19, 1995 Magnetic Cloud**,L. Janoo, C.J. Farrugia, R.B. Torbert, J.M. Quinn, A. Szabo, R.P. Lepping, K.W. Ogilvie, R.P. Lin, D. Larson, J.D. Scudder, V.A. Osherovich, J.T. Steinberg, to appear JGR, 1998.

UIowa Polar/Hydra Published Papers

- **Polar observations of convection with northward interplanetary magnetic field at dayside high latitudes**, N.C. Maynard, W.J. Burke, D.R. Weimer, F.S. Mozer, J.D. Scudder, C.T. Russell, and W.K. Peterson, JGR., 103, 29, 1998

- **Identification of magnetospheric particles that travel between spacecraft and their use to help obtain magnetospheric potential distributions**, E.C. Whipple, J. Halekas, J.D. Scudder, W.R. Paterson, L.A. Frank, R.B. Sheldon, N.C. Maynard, C.T. Russell, K. Tsuruda, H. Hayakawa, and T., Yamamoto, JGR, 103, 93, 1998.

- **The electron drift instrument for Cluster**,Paschmann, et al (including Whipple) Space Sci. Rev., Vol. 79, pg. 233, 1997.

- **Theoretical approaches to the description of magnetic merging: The need for finite beta_e, anisotropic ambipolar Hall MHD**, J.D. Scudder, Space Sci. Rev., Vol. 80, pg. 235, 1997.

UIowa Polar/Hydra Online Papers

- **A Comparison of a Model for the Theta Aurora With Observations From Polar, Wind, and SuperDARN**

S.-W. Chang, J. D. Scudder, J. B. Sigwarth, L. A. Frank, N. C. Maynard, W. J. Burke, W. K. Peterson, E. G. Shelley, R. Friedel, J. B. Blake, R. A. Greenwald, R. P. Lepping, G. J. Sofko, J.-P. Villain, and M. Lester
J. Geophys. Res., in press, 1997

UIowa Polar/HYDRA Workshops/Meetings Presentations

1998 Western Pacific AGU Meeting, Taipei:
Polar Wind Measurements with TIDE/PSI and HYDRA on the POLAR spacecraft

1. Y.-J. Su, J. L. Horwitz (Center for Space Plasma and Aeronomic Research, The University of Alabama in Huntsville, Huntsville, AL 35899; 205-890-5137; suy@cspar.uah.edu),
2. T. E. Moore, B. L. Giles (Goddard Space Flight Center, Greenbelt, MD 20771),
3. M. O. Chandler, P. D. Craven (Marshall Space Flight Center, Huntsville, AL 35812),
4. S.-W. Chang and J. D. Scudder (University of Iowa, Iowa City, Iowa 52242)

The Thermal Ion Dynamics Experiment (TIDE) on the POLAR spacecraft has allowed sampling of the three-dimensional ion distributions with excellent energy, angular, and mass resolution. The companion Plasma Source Instrument, when operated, allows sufficient diminution of the electric potential to observe the polar wind at very high altitudes. In this presentation, we will describe the results of polar wind characteristics H$^+$, He$^+$, and O$^+$ as observed by TIDE at 5000 km and 8 R_E altitudes. The relationship of the polar wind parameters with the solar zenith angle and with the day-night distance in the Solar Magnetic coordinate system will also be presented. We will compare these measurements with recent simulations of the photoelectron-driiven polar wind using a couple fluid-semikinetic model [Su et al., 1998]. In addition, we will compare these polar wind observations with low-energy electrons sampled by the HYDRA experiment on POLAR to examine possible effects of the polar rain and photoelectrons and hopefully explain the large ion ouflow velocity variations at POLAR apogee.

Su, Y.-J., J. L. Horwitz, G. R. Wilson, P. G. Richards, D. G. Brown, and C. W. Ho, Self-consistent coupled fluid-semikinetic simulation of the photoelectron-driven polar wind from 120 km to 9 R_E altitude, J. Geophys. Res., 103, 2279, 1998.

Geospace Environment Modeling Workshop, Snowmass, CO:
C. A. Kletzing, J. D. Scudder, **Polar Observations of the Plasma Sheet between the Magnetotail and the Ionosphere**, June, 1997.

National Radio Science Meeting
Boulder, CO.
Jan, 1998

THE AURORAL SOURCE REGION: POLAR PLASMA OBSERVATIONS ABOVE THE AURORAL ACCELERATION ZONE

1. C. A. Kletzing
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NASA's Polar spacecraft regularly samples the high latitude extension of the Earth's plasmasheet at distances of the order of 6 R_E geocentric. This region connects to the Earth's auroral zone at low altitude. At these altitudes the plasmasheet electrons measured by the Hydra particle spectrometer are the unaccelerated source population of hot magnetospheric electrons which feed the auroral acceleration region. Statistically, this plasma shows a range of electron density of 0.01-0.5 cm^{-3} and a range of electron temperature of 100-5000 eV. The two quantities are not correlated. Within a single traversal of this region, the plasma can be quite homogeneous or quite variable in density and/or temperature. In addition, the EFI experiment on Polar observes spiky electric fields when in this high latitude auroral source region. Spiky electric field measurements near the plasma sheet boundary have been reported from spacecraft making measurements of the plasma sheet near the equatorial plane and at much larger distances from the Earth. For the Polar observations, however, it is not clear that these fields are always located on boundary between the plasma sheet field lines and polar cap/lobe field lines. In general, these fields do appear at boundaries between regions of differing temperature and/or density in the Hydra particle measurements, but these boundaries often occur within the plasma sheet and thus the electric fields are imbedded within the plasma sheet and not at its edge. Moreover, the presence of boundaries in temperature and density does is not always correlated with electric field signatures.

Seven talks by Elden Whipple all on the topic of identifying and using magnetospheric particles that travel between spacecraft:

1. At AGU, December, 1996
2. At the University of Washington, May, 1997
3. At UCSD, July, 1997
4. At Boston University, September, 1997
5. At the University of New Hampshire, October, 1997
6. At AGU, December, 1997
7. At ESTEC, February, 1998

UIowa Polar/HYDRA Fall 1996 AGU Abstracts

Cusp Electrodynamics with Northward IMF, Observed by POLAR

1. N C Maynard and D R Weimer (Mission Research Corp., Mashua, NH)
2. W J Burke (Phillips Laboratory, Manscom AFB, MA)
3. F S Mozer (Physics Dept., Univ. of Calif., Berkeley, CA)
4. J D Scudder (Physics Dept., University of Iowa, Iowa City, IA)
5. C T Russell (UCLA, Los Angeles, CA)
6. R P Lepping and K W Ogilvie (NASA/GSFC, Greenbelt, MD)
7. W K Peterson (Lockheed Martin, Palo Alto, CA)
8. H E Spence (Boston University, Boston, MA)

We present simulataneous measurements of electric/magnetic fields and energetic particle fluxes acquired during two passes of POLAR through the northern cusp. The WIND satellite determined that in both instances the interplanetary magnetic field (IMF) had northward components, and similar clock angles in the Y_GSM-Z_GSM plane. The solar wind velocities were similar. Where possible, we compare the electric field signatures detected at altitudes near 5 R_E with observations from DMSP and predictions of convection models. Electric fields encountered during cusp passges at high altitudes are marked by very large variabilities extending from the PC 1 through the PC 4 ranges. Although the orbital paths of POLAR during the two cusp passes followed similar trajectories in MLT and invariant latitude, the large-scale dynamics encountered were very different. In one instance the downward moving ions displayed a reverse, velocity-dispersion feature, indicating that POLAR crossed a projection of the merging line to middle altitudes. Our electric field model indicates that the observed signatures result from an encounter with a lobe convection cell. In the other case, the region of cusp-like particle fluxes appears rather quiescent. Here the model correctly predicted that, with the slightly changed input conditions, POLAR should pass through a region of relative stagnation.

Polar Observations of ULF Plasma Waves in the Cusp

1. R F Pfaff, J Clemmons, J Johnson (Laboratory for Extraterrestrial Physics, NASA/Goddard Space Flight Center)
2. N Maynard, D Weimer (Mission Research Corp., Nashua, NH)
3. W Burke (Phillips Lab., Hanscom AFB, MA)
4. F Mozer (Physics Dept., Univ. of Calif., Berkeley, CA)
5. C Russell (IGPP, Univ. of Calif., Los Angeles, CA)
6. J Scudder (Physics Dept., University of Iowa, Iowa City, IA)

The Polar Spacecraft has encountered the earth's cusp on numerous occasions during its first 4 months in orbit. Intense (5-10 mV/m, rms), localized ULF electric field structures are a consistent feature of these cusp encounters, which are also characterized by localized keV dispersed ion "injections". Distinct magnetic field perturbations, evident in the Polar Magnetometer data, are also commonly associated with these cusp encounters, and reveal evidence for Alfvenic wave structures and field-aligned and filamentary currents. By analyzing simulataneous measurements of the electric and the magnetic field components of the ULF plasma waves, we will address the energy flow associated with the wave field

and provide important information concerning the source region of the waves. We examine in detail two typical cusp encounters in which the IMF Bz is southwards, in order to understand the complex relation of the ULF waves with the DC electric fields, ambient plasma density, and the cusp energetic particle poplulation. The observations address several aspects of cusp-driven wave instabilities as well as other, larger-scale processes.

Extreme Magnetic Field Conditions at Geosynchronous Orbit During the October 18, 1995 Magnetic Cloud Event

1. H J Singer and T Onsager (NOAA R/E/SE, Space Environment Center, 325 Broadway, Boulder CO 80303; 303-497-6959; hsinger@sec.noaa.gov)
2. C J Farrugia (Institute for the Study of Earth, Oceans, and Space, Univ. of New Hampshire, Durham, N.H. 03824)
3. A Lazarus and J Steinberg (Center for Space Research, Massachusetts Institute of Technology, Cambridge, MA. 02139)
4. R P Lepping (Laboratory for Extraterrestrial Physics, NASA/GSFC, Greenbelt, Md. 20771)
5. G Lu (High Altitude Observatory, NCAR, Boulder, CO 80303)
6. G Rostoker (Department of Physics, University of Alberta, Edmonton, Alberta, Canada T6G 2J1)

On October 18, 1995 a magnetic cloud was observed in the solar wind by the WIND spacecraft just before it encountered the Earth*s magnetosphere. Many of the features associated with the cloud, such as the shock, changes in the solar wind density, and changes in the IMF Bz component, affected the magnetic field observed at geosynchronous orbit through changes in various magnetospheric current systems. These effects will be described, with particular attention on an interval when the magnetic field at GOES 9, located at about 1620 LT, became severely distorted so as to have a southward orientation, which is usually interpreted as a magnetopause crossing at geosynchronous orbit. However, this disturbance occurred at a time when the solar wind dynamic pressure was insufficient to move the magnetopause in to the geosynchronous location. The conditions that produced this extreme distortion of the geosynchronous magnetic field will be described, and comparisons of GOES magnetic field observations will be made with ground magnetometer data from the Canadian CANOPUS magnetometer network as well as magnetic field models. In addition, field-aligned currents derived from the Assimilative Mapping of Ionospheric Electrodynamics (AMIE) model and projected from the ionosphere to the magnetospheric equatorial plane will be compared to the observed magnetic field perturbations.

ULF Electric Fields in the Dayside Magnetosphere: Results from POLAR

1. J H Clemmons, R F Pfaff, S Kanekal, F Herrero
   NASA/Goddard Space Flight Center, Greenbelt, MD 20771
2. F S Mozer, Space Sciences Laboratory, University of California, Berkeley, CA 94720
3. P J Chi, C T Russell
   Institute of Geophysics and Planetary Physics, University of California, Los Angeles, CA 90095
4. J D Scudder, University of Iowa, Iowa City, IA
5. A T Weatherwax, University of Maryland, College Park, MD
6. L J Lanzerotti, Bell Laboratories, Lucent Technologies, Murray Hill, NJ
7. H Vo, University of Calgary, Calgary, Alberta, Canada

The POLAR satellite has accumulated many observations of ultra-low frequency (ULF) waves during traversals through the dayside magnetosphere. These waves are studied using a technique which employs vector electric field measurements from the Electric Field Investigation (EFI) on POLAR to complement the usual magnetic field measurements. The additional information allows better determination of, e.g., phase and mode structure. Comparisons with measurements from ground-based instruments yield further insight into the mode structure and polarization of the waves. The interaction of the waves with the ambient charged particle populations is also discussed.

ISTP/GGS Observations During Passage on May 27,1996 of a Magnetic Hole in Front of a Magnetic Cloud: A Coordinated Ground and Spacecraft Study

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On May 27,1996 the WIND spacecraft, situated approximately 150 Re upstream of Earth and close to the Sun-Earth line, encountered an interplanetary magnetic cloud starting at about 1430 UT which lasted for more than a day. The cloud was preceded by a magnetic hole and a solar wind dynamic pressure pulse of nearly 3 hours duration, where the sum of the proton and magnetic pressures was approximately constant; the proton density had a threefold increase, with a corresponding strong and sharp rise in the dynamic pressure. South Pole Station, at 74 degrees magnetic latitude, was favorably situated in the prenoon sector (1100 MLT at 1430 UT) to examine the high latitude dayside response of the ionosphere to the solar wind variations. The onset and termination of the most intense auroral luminosity and auroral absorption activity at South Pole Station, characterized by a hard spectrum of precipitated electrons, correlates very closely with the onset and termination of the solar wind pressure pulse, allowing for an expected 40-50 min propagation delay for disturbances at WIND to reach the magnetopause. Details of this association and other higher resolution features of the data, including Pc 5 and Pc 3 pulsations and broadband VLF emission spikes, will be presented and the implications for solar wind-magnetosphere-ionosphere coupling discussed.

The Source Population for Auroral Electrons as Observed by the Hydra Plasma Analyzer on Polar

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Several theories of auroral particle acceleration have as their basis a population of electrons with characteristic temperature around 1 keV and density of 1/cc which is accelerated by a field aligned potential drop to the characteristic 1-10 keV auroral electron energy. This source population is also suggested by several studies which have fit the tail of the accelerated auroral distribution to derive the

electron source population density and temperature. The Hydra electron and ion spectrometer on the Polar spacecraft provides an excellent opportunity to study this source population. The Polar orbit provides a high altitude profile (typically greater than 4 R_E) of the nightside plasma sheet population once per orbit as it crosses high latitude field lines which map to the plasma sheet. This gives an effective radial profile of the plasma sheet as the field lines which Polar crosses map to radial distances from the Earth. Because of the high altitude, these measurements are above the auroral acceleration region allowing us to directly view those electrons which are accelerated below. We present a study of plasma sheet density and temperature and discuss how this population varies as a function of solar wind and IMF parameters as measured on the Wind spacecraft.

Separatrix Crossings and Possible Penetration of the Diffusion Region in an Example of Reconnection, Poleward of the Cusp

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P. Puhl-Quinn (UI), J.B. Faden (UI), H.J.Cai (UI),
K.W. Ogilvie (NASA GSFC-LEP), C. Farrugia (UNH), C.T. Russell (UCLA)

Electron and ion signatures from the Polar HYDRA spectrometers and the onboard high resolution magnetic field data from MFE are used to suggest a magnetohydrodynamic frame work for examing the unusual cusp encounter witnessed by the Polar instrument complement on May 29, 1996. The magnetosphere was deformed by the interplanetary magnetic cloud as documented by the GGS Wind spacecraft particle and magnetic field data. Ambient densities in the cusp vicinity were approximately 80/cc. The northward IMF is favorable for cusp reconnection polarward of the cusp.

The HYDRA data for density, temperature, anisotropy, flow speed, heat flux, and energy time spectrograms are used to delineate the possible configurations of the adjustments in the cusp region required by the volatile interplanetary and draped sheath magnetic field configuration. Heat fluxes, particle anisotropies, dispersions and convection signatures (reflective of stress release) will be used to suggest the wordline for the Polar spacecraft during the encounter. The incidence of flat-topped electron distributions will also be used to diagnose locations in the flow. Multiple crossings of separatrices have been identified in the time series and their sense of heat flow in relation to the magnetic field will be used to ascertain the location in time of observations in relationship to a possible separatrix. The trajectory of Polar appears to have skimmed just inside the nominal magnetopause, moving from below the separator line to above it, possibly having actually penetrated the diffusion region. In so doing it definitely pierced the separatrix on two separate sheets and skimmed the outermost separatrix sheets on brief occasions.

Heat flow pattern near an X line in collisionless magnetic reconnection

H. J. Cai and J. D. Scudder

It is reported that there are significant heat flows near the diffusion region during magnetic reconnection from satellite observations [Scudder et al., in Magnetic Reconnection in Space and Laboratory Plasmas, Ed. E. W. Hones, 1984; Fuselier et al., JGR, 100, 11885, 1995]. We study the heat flow pattern near a magnetic X line based on two-dimensional full particle simulation. The self-consistently obtained heat flux and the corresponding magnetic field, plasma density, plasma flow, electron temperature and

pressure anisotropy through layers would help us to understand what pattern a spacecraft experiment might "see" passing through the diffusion region.

Remote Sensing of Magnetospheric Structure Using (U, B, K) Analysis of ISTP Particle and Field Data

E. C. Whipple, J. S. Halekas, University of Washington
R. B. Sheldon, Boston University, J. D. Scudder, University of Iowa

Magnetospheric measurements with instruments on ISTP spacecraft exhibit complex particle and field structures: co-existing hot and cold plasmas, different flows for different species, and boundaries between different populations. These features are clues to the variety of processes affecting magnetospheric structure and require a sophisticated analysis to gain quantitative understanding.

We describe the (U, B, K) coordinate system (U = electric potential, B = magnetic field magnitude, K = longitudinal invariant). Mirror points follow straight lines in this system. Particle trajectories and access to magnetospheric regions are easily visualized, providing a remote sensing capability. Computations involve the 3D task of mapping between coordinates, not the 6D task of following particles.

We discuss several applications of this analysis technique. When used together with electric and magnetic field models one can find charged particles that travel between different ISTP spacecraft. Liouville's theorem can be used to obtain the difference in electrostatic potential between the spacecraft locations and to test and/or correct the models. We apply this analysis to data from several ISTP spacecraft during a reasonably quiet period when they are in the near tail region of the magnetosphere.

Polar Hydra Particle Data -- Comparisons with Auroral Sounding Rocket Observations

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R. L. Arnoldy and R. B. Torbert,Space Science Ctr, Univ of New Hampshire
C. A. Kletzing and J. D. Scudder, Physics Dept, Univ of Iowa
P. M. Kintner, Cornell University

The Hydra Hot Plasma Analyer onboard the Polar spacecraft measures particle phase space distributions of electrons and ions from 1~eV to 30~keV. The trajectory of the polar-orbiting spacecraft provides north-south auroral zone crossings at varying magnetic local times, at approximately 5~Re altitude in the northern hemisphere, and about 1~Re altitude in the southern hemisphere. These data provide an excelle framework for placing auroral sounding rocket observations into a larger scale picture.

In this paper we will compare the Polar Hydra particle data to particle and field data from the AMICIST, SCIFER, and Topaz3 sounding rockets. AMICIST and Topaz3 were nightside auroral zone passes; SCIFER was a dayside auroral zone pass. In particular, the SCIFER data show in great detail an example of the changeover from closed to open magnetic field lines as a function of magnetic latitude; we shall show examples of this type of crossing from Polar Hydra data which vary with Kp and magnetic local time. Comparisons of this sort allow the high resolution microphysics of sounding rocket data to be put into a macrophysical picture.

Comparison of Auroral X-ray Emissions with Simultaneously Measured Energetic Electron Precipitation

P. C. Anderson, D. Chenette, D. L. McKenzie, J. M. Quinn, and M. Grande

The Polar Ionospheric X-ray Instrument Experiment (PIXIE) on board NASA's POLAR spacecraft is an X-ray multiple-pinhole camera designed to image the auroral oval and provide information on the spatial and temporal distribution of the atmospheric bremsstrahlung X-ray emissions in the energy range 2 - 60 keV. The simple relationship between the X-rays and the precipitating electrons producing them and the auroral ionization allows us to obtain electron density and conductivity profiles for each point imaged by the instrument. On May, 27, 1996, PIXIE was imaging the southern auroral oval during a POLAR perigee pass (1.8 Re) at the time of a substorm. At the same time, the low-altitude DMSP F12, F13, and SAMPEX spacecraft were crossing the southern auroral oval and passing through the PIXIE field of view. The DMSP spacecraft instruments provided measurements of the energetic precipitating electrons in the energy range 30 eV to 31 keV while the SAMPEX instruments provided measurements above 25 keV. At very nearly the same time that PIXIE was imaging the auroral oval, the HYDRA and CEPPAD instruments on board POLAR provided measurements of the precipitating electrons in the energy ranges 10 eV to 20 keV and above 25 keV respectively. Thus we were able to acquire the distribution of the energetic electron precipitation at several locations in the auroral oval simultaneously with the energy distribution of the X-rays produced by those electrons. We compare the measured energetic electron distributions with distributions derived from the x-ray measurements to demonstrate how well the x-ray measurements can be used to determine the energy distribution and total intensity of the precipitating electrons, and then apply these results to produce global maps of auroral conductivities.

Latitudinal Profiles of Ring Current Ions During Moderate Geomagnetic Activity

V. K. Jordanova, J. M. Quinn, C. J. Farrugia, L. Janoo (all at: Space Science Center, University of New Hampshire)
J. E. Borovsky (Los Alamos Nat. Lab.)
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We study the storm activity during the time interval March 20-22, 1996. Interplanetary conditions, monitored by WIND and IMP 8, show fluctuations about zero in the (GSM) Bz component, which are due to Alfven waves in a stream-stream interaction region. The corresponding preliminary Dst shows general activity punctuated by 2 moderate storms (min Dst~-50 nT and ~-60 nT, respectively) of ~15 hou duration each. The ring current development during this period is studied using the model of Jordanova et al. [1996]. The model solves the kinetic equation for the phase space distribution function, considering losses due to charge exchange, Coulomb collisions and wave-particle interactions along ion drift paths. The magnetospheric electric fields are calculated with a Kp dependent Volland-Stern electric field model. The statistical quiet time ring current spectra of Sheldon and Hamilton [1993] are used as initial conditions. The boundary conditions are updated throughout the storm period according to measurements provided by the instruments on the Los Alamos geosynchronous satellites. The ring current distributions as a function of radial distance in the equatorial plane, MLT, energy and pitch angle are calculated as the storm evolved. The latitudinal profiles of ring current ions are obtained and compared with measurements provided by the HYDRA, TIMAS and CEPPAD instruments on the POLAR spacecraft. The role of different mechanisms in their formation is studied.

Jordanova et al., submitted to J. Geophys. Res., 1996.
Sheldon and Hamilton, J. Geophys. Res., 98, 13491, 1993.

Magnetic Field and Plasma Observations made by Wind on May 27-30, 1996: Triggers of Magnetospheric Activity

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To support the study of ground and spacecraft observations made on May 27 - 29, 1996, we describe magnetic field and plasma observations made by the magnetic field experiment and the plasma instrument on the GGS mission spacecraft WIND. For the period, complete and detailed observations are available. Broadly, the interplanetary medium is dominated by a magnetic cloud (May 27-28) which is being overtaken by a corotating stream, forming a highly-structured interaction region May 29. The magnetic cloud, which we model by an expanding Lundquist magnetic flux rope, is preceded by a 4-hour period where B drops occasionally to value 1-2 nT and n has a fourfold enhancement to 18 cm^-3. After an abrupt southward turning, the cloud field rotates generally from south to north. Except for the rear, the cloud field has also strong eastward and antisunward components. For 30 hours within the cloud there occurs a quasilinear increase in the density (from 5 to 20 cm^-3) On the general south-north rotation of the cloud field are superimposed short-period, purely Alfvenic fluctuations. The Alfven Mach number, a useful parameter in cloud-magnetosphere interactions, is untypically high within the cloud (6-9). The relative He++/H+ concentration is below 2%. On early May 29, the enhanced (13 nT), strongly northward fields (due to the cloud-stream interactions), coupled with high densities (30 cm^-3); due to an encounter with the heliospheric plasma sheet) present conditions very favourable for reconnection tailward of the cusp in the near-summer northern hemisphere. Indeed, HYDRA data appear to substantiate this expectation. On late May 29, WIND observes a highly-structured, plasma-dominated medium: there occur quasi-periodic decreases in field strength which are accompanied by bursts of enhanced proton beta (10) and Alfven Mach number (40). The dynamic pressure remains high throughout May 29. These and other features are relevant to the understanding of the rich variety of inner and outer magnetospheric effects seen in this period.

UIowa Polar/HYDRA Spring 1997 AGU Abstracts

Cold electrons and ions measured by Polar/Hydra on the field lines connected to the inner edge of the plasma sheet

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It is recognized that the substorm onset may take place in the transition region between the tail-like magnetic field and the dipolar geomagnetic field. A detail measurement of the inner edge of plasma sheet is therefore of great importance. The Hydra plasma analyzer on the Polar spacecraft provides an opportunity to study the plasma population magnetically connected to the inner edge of the plasma sheet. Preliminary results show that there is a cold population of plasma adjacent to the plasma sheet but at lower latitudes. The density of the cold electrons is about $2-6 cm^{-3}$ and the temperature is about $15-50 eV$ in contrast to the plasma sheet electrons with density of $\sim 1 cm^{-3}$ and temperature of $\sim 1 keV$. The cold electron population is sometimes seen to be accompanied by cold ions detected by the Hydra plasma analyzer in the lowest energy range when spacecraft potentials permit. The existence of the high density cold plasma also leads to a sharp gradient of plasma density near the inner edge of the plasma sheet, which in turn makes the inner edge of the plasma sheet a possible source region of the magnetic field line resonance.

UIowa Polar/HYDRA Fall 1997 AGU Abstracts

High Altitude Auroral Zone Plasma and Electric Fields

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2. J. D. Scudder, University of Iowa, Iowa City, IA
3. J. A. Wygant
4. F. S. Mozer

A comparison between electron and ion spectra and electric fields measured by the Hydra particle analyzer and the EFI experiment on NASA's Polar spacecraft is presented for times when Polar was in the high latitude extension of the plasma sheet at altitudes of 5-7 R_E. This region connects to the Earth's auroral zone at low altitude. Spiky electric fields measurements near the plasma sheet boundary have been reported from spacecraft making measurements of the plasma sheet near the equatorial plane and at much larger distances from the Earth. Polar also observes spiky electric fields as well as wave fields of varying intensities, but it is not clear that these fields are always located on boundary between the plasma sheet field lines and polar cap/lobe field lines. In general, these fields do appear at boundaries between regions of differing temperature and/or density in the Hydra particle measurements, but these boundaries often occur within the plasma sheet and thus the electric fields are imbedded within the plasma sheet and not at its edge. Moreover, the presence of boundaries in temperature and density does is not always correlated with electric field signatures. Several examples are presented along with preliminary statistics.

Mono-directional Auroral Electron Beams at Great Altitudes

1. C.E. McIlwain
2. W. Fillius
3. S.S. Kerr
4. E.C. Whipple
5. J.D. Scudder

Auroral ion and electron beams at very high altitude were first observed by the UCSD detectors on the geosynchronous spacecraft ATS-6 [1]. Instruments on the Polar spacecraft are now regularly observing beams of both ions and electrons. For one half second, twice every six second spin period, the two HYDRA PPA detectors measure the angular distribution of electrons in the direction of the magnetic field, and simultaneously, the angular distribution in the direction antiparallel to the magnetic field [2]. Electron beams are frequently observed by the PPA at energies of several hundred eV, and sometimes at over 5000 eV. In the northern hemisphere at 4 Earth radii and beyond, the beams are typically unidirectional, and are often concentrated within one degree of the antiparallel direction. These beams were presumably formed, only seconds before being observed, by ionospheric electrons that were accelerated in parallel electric fields associated with the aurora.

[1] McIlwain, C. E., Auroral Electron Beams Near the Magnetic Equator, Physics of the Hot Plasma in the Magnetosphere, ed. Hultqvist, B. and L. Stenflo, Plenum Pub. Corp., New York, 1975.
[2] For further description of the Hydra instruments, see: Space Science Reviews, 71, 459-495, 1995.

The present results of the HYDRA investigation would not have been possible without the decade-long hardware efforts led at NASA GSFC by Keith Ogilvie, at UNH by Roy Torbert, at Max Planck Lindau by Axel Korth and at UCSD by Walker Fillius. The PPA instrument required the dedicated efforts of Fred Herrerro, John Keller, Dennis Chornay, Pamela Puhl- Quinn and Robert Holdaway. The research for this paper was made possible by HYDRA NASA funding under grant number NAG 5 2231 and DARA under grant 50 OC 8911 0.

Generation of the Theta Aurora

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6. J. B. Blake (The Aerospace Corporation, Los Angeles, CA)
7. C. T. Russell (Institute of Geophysics and Planetary Physics, UCLA, Los Angeles, CA)
8. R. A. Greenwald (Johns Hopkins Applied Physics Laboratory, Laurel, MD)
9. R. P. Lepping (Goddard Space Flight Center, NASA, Greenbelt, MD)
10. G. J. Sofko (Institute of Space and Atmospheric Studies, U. of Saskatchewan,Saskatoon, Canada)
11. J.-P. Villain (Laboratoire de Physique et Chimie de l'Environnement Centre National de la Recherche Scientifique, Orleans, France)
12. M. Lester (Dept. of Physics and Astronomy, U. of Leicester, Leicester, United Kingdom)

A model is presented according to which theta auroral arcs form after southward turnings of IMF Bz and/or large variations in By, following prolonged periods of northward IMF or very small Bz, with |By| greater than or comparable to |Bz|. The arcs start on the dawn (dusk) side of the auroral oval and drift duskward (dawnward) across the polar cap for positive (negative) By in the northern hemisphere and conversely in the southern hemisphere. After the theta aurora has formed, changes in IMF By or Bz readjust the merging configuration and continue the auroral pattern. The transpolar arcs are on closed magnetic field lines that bifurcate two open sections of the polar cap and map to the outer plasma sheet. Observations from the ISTP/GGS Polar and Wind spacecraft and the ground-based SuperDARN radars that are consistent with the predictions of the model include: (1) The formation and evolution of theta auroras observed by VIS are closely related to the IMF patterns measured by MFI. (2) Both electrons and ions in the transpolar arc and poleward part of the nightside auroral oval exhibit similar spectral characteristics, identified by Hydra and CEPPAD. The low energy electrons show counter streaming distributions, consistent with their being on closed field lines that magnetically connect to the boundary plasma sheet in the magnetotail. (3) Ion composition measurements obtained from TIMAS show cold plasma outflows from the ionosphere and hot, isotropic magnetospheric ions in the two regions, also indicating transpolar arcs are on closed field lines. (4) Large scale polar cap convection inferred by SuperDARN observations is well anti-correlated with IMF Bz variations. (5) Plasma convection in the transpolar arcs, inferred from EFI electric field and MFE magnetic field measurements, is sunward. (6) Transpolar arcs are located in regions of upward field-aligned currents observed with MFE.

This research is supported by HYDRA NASA funding under grant number NAG 5 2231 and DARA under grant 50 OC 8911 0. Support for the VIS Earth Camera data acquisition at The University of Iowa is provided by NASA under NAS5-30316. SuperDARN observations are supported by Grants NASA

Grant NAG5-1099 and NSF Grant ATM-9502993.

Observations of polar cap electron modulation under a wide variety of interplanetary conditions

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2. J.D. Scudder, (University of Iowa)
3. K.W. Ogilvie, R.J. Fitzenreiter, R.P. Lepping, (NASA GSFC)
4. A.J. Lazarus, J.T. Steinberg (Massachusetts Institute of Technology)

Field aligned, solar wind electrons carrying heat flux from the sun (strahl) gain access to the magnetosphere through the magnetotail and may precipitate in the polar cap as polar rain. We present observations of electron fluxes, at energies of several hundred eV, in the northern and southern polar cap using measurements by Hydra on the Polar spacecraft, in conjunction with measurements of the interplanetary medium from the MFI and SWE instruments on Wind. In order to test mechanisms for control of polar cap electrons by interplanetary conditions we present selected case studies in which isolated, or clearly defined, variations in the polar cap may be directly linked to specific variations in the solar wind. We present results from events of three general types, selected from over 1 year of coordinated Wind and Polar observations: (1) sharp, step-like changes in polar rain intensity between two otherwise uniform levels; (2) well defined structures in the interplanetary medium, such as the fluctuations in IMF clock angle during Alfven wave trains and variations in strahl electron fluxes; and (3) periods before, during, and after the passage of solar ejecta, which include intervals of unusualy strong IMF components of several hours duration. By including such wide ranges of interplanetary conditions, we are able to extend previous work under more typical solar wind.

Observation of a Correspondence Between Poleward-Moving Auroral Forms and Stepped cusp ion Precipitation

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In a case study, we document for the first time a one-to-one association between three auroral forms which are separated in latitude and moving poleward, and three intervals of almost constant, but different, low-energy cutoffs in the ion precipitation in the cusp region ("stepped cusp" precipitation). The ground observations are from Ny Alesund at 75 deg MLAT, and the precipitation pattern is observed by the DMSP F13 satellite as it crosses the noon meridian into the morning sector. The energy cutoffs increase with decreasing latitude. The auroral forms brighten up at different times but at practically the same MLAT (about 73 deg), and start fading 5 min later at about 76 deg MLAT. Interplanetary conditions, monitored by WIND, show a stable, slow and cold solar wind with an IMF which points southwest. Staircase ion precipitation signatures such as observed in this example have

been successfully interpreted in terms of a sequence of reconnection bursts at the low-latitude, dayside magnetopause. The time history of the auroral activity observed from the ground confirms this interpretation. We exclude the possibility that the auroral forms are triggered by changes in the interplanetary medium because the latter is very steady.
(Poster presentation: no special gadgets).
presenting author: C J Farrugia (UNH)

Kelvin-Helmholtz Instabilty at the Dayside Magnetopause and its Boundary Layers for Strongly Northward IMF

1. F T Gratton
2. C J Farrugia
3. L Bender
4. R B Torbert
5. J M Quinn,
6. N V Erkaev
7. H K Biernat

The Kelvin-Helmholtz (KH) instability at the magnetopause may be an important contributor to ''viscous-type'' coupling of solar wind energy and momentum to the magnetosphere. The instability may also develop at the inner edge of the boundary layer (IEBL). Perturbations at the two interfaces may on occasion be coupled. In recent data analyses, there is some uncertainty as to which surface (magnetopause/IEBL) has been perturbed. We present results from a recent work, applicable to strongly northward-pointing IMF, in which (a) physical parameters in the plasma depletion layer are computed as input to the calculation of KH growth rates, and (b) effects of magnetopause accelerations are incorporated in a generalized dispersion relation. Maximum growth rates at points of a computational mesh are calculated from which growth rate maps covering the whole dayside are drawn. The configuration includes a boundary layer, and the various regions are modelled by piecewise constant functions. The calculations show a dawn-dusk asymmetry in KH growth rate maps when the IMF is inclined to due north. There are cases where the magnetopause and the inner edge of the BL may be separately unstable to different modes. When thus decoupled, the inner edge of the BL is generally more prone to be unstable. There are other instances, however, where the motions of the magnetopause and inner edge are coupled, with both surfaces unstable. It is possible that some interpretative difficulties may be overcome when this second possibility, which has been often neglected in recent observational work, is considered.

presenting author: Charles Farrugia. POSTER

EXCITATION OF RIGHT-HANDED ELECTROMAGNETIC ION CYCLOTRON WAVES IN SOLAR EJECTA WITH LARGE PARALLEL-TO-PERPENDICULAR TEMPERATURE RATIOS

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2. Charles J. Farrugia, Institute for the Study of Earth, Oceans, and Space, University of New Hampshire, Durham, NH, USA
3. Keith W. Ogilvie, NASA/Goddard Space Flight Center, Greenbelt, MD, USA

Coronal mass ejections (CME's) form a statistically heterogeneous set of objects characterized by (i) low proton temperature, T_p and (ii) bidirectional streaming of heat flux electrons. In a number of CMEs, the relative α-to-H$^+$ concentration, η_{α}, is above typical solar wind values, and the proton temperature anisotropy is negative, i.e., $T_{p,\parallel}>T_{p,\perp}$. The negative anisotropy, opposite to that of the fast solar wind, allows us to predict important changes in the power spectrum of electromagnetic ion cyclotron waves (EICW), such as the excitation of right-hand polarized waves (stable in the fast solar wind) in a frequency range near the proton cyclotron frequency. This instability, being an extension to higher frequencies of the firehose mechanism, is not expected to arise in low proton beta CMEs. Nevertheless, we show that (a) a high η_{α}, and (b) an enhancement of the parallel over average beta may lead in many cases to e-folding times which are longer than ejecta evolution times. We present a systematic analysis of the influence of variations of CME physical parameters on the EICW growth rates, pivoting around a reference $\beta_{p}=0.4$. Magnetic clouds are a subset of CMEs with more homogeneous properties, but, with typical betas = 0.1, the right-hand branch of the instability is not usually excited. However, many magnetic clouds have $T_{e}>>T_{p}$, and $T_{p,\parallel}>>T_{p,\perp}$. On occasion there are regions in magnetic clouds where $\eta_{\alpha} \sim 0.10 - 0.15$, $T_{p,\parallel}/T_{p,\perp}\sim 6-10$, and $T_{e}/T_{p}\sim 10$. Under such conditions the influence of the electron thermal parameters on the right-hand polarized EICW instability properties (minor when $T_{e}/T_{p}\sim 1$, as in the solar wind) may become very important. We find that $\beta_{p} \sim 0.1$ combined with electron temperature anisotropy, $T_{e,\parallel}>>T_{e,\perp}$, can substantially raise the growth rates of the right-hand instability also in low beta clouds. Analysis of low frequency power spectra observed by the Global Geospace Mission spacecraft WIND in the light of these results is under way.
This work partially supported by NASA grant NAG5-2834 and BID-CONICET grant PIP046.
presenting author : Charles Farrugia, format : poster

An indication of plasmaspheric population being energized into plasma sheet population

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Based on measurements by Hydra plasma analyzer on the Polar spacecraft, we identified that at times there is an extra plasma component at the inner edge of the plasma sheet. This plasma component has a density and a mean energy in-between those of the plasmaspheric plasma population and the plasma sheet population. The extra plasma component is found in the transition region of a sharp plasma density gradient (a sharp gradient of the Alfven velocity) and accompanied by enhanced low frequency electric field fluctuations. The pitch-angle distribution of the electrons usually has a field-aligned feature. We suggest that the existence of the intermediate plasma component indicates that the plasmaspheric plasma can be energized into the plasma sheet plasma, most probably as a result of Alfven wave resonant heating near the inner edge of the plasma sheet. This finding may also provide a clue of how the plasmasphere is eroded and how the injection boundary forms.

Ejecta, also Interplanetary Magnetic Clouds, in the context of the Sun-Earth Connection (During this Solar Minimum)

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The ISTP spacecraft WIND and SOHO, since their launch in late 1994 and late 1995 respectively, have been in the solar wind (SW) upstream of the Earth. These ISTP missions have observed a substantial number of ejecta. Some of them (e.g. Oct. , and May 15, 97) generated a strong geomagnetic response. For these and other ejecta observed in situ by SW instruments on WIND we will compare their signature in the atmosphere of the Sun, e.g. the presence/absence of flares, Moreton waves, an the injection of energetic particles in the SW. We will also compare the initial direction and velocity of propagation of the ejecta. In the interplanetary medium we will look at the appearance, or non-appearance, upstream of the ejecta of a piston-like shock, driven by the ejecta, their orientation in the SW, presence of minutes-wide magnetic holes, association or not of the ejecta to a high-low stream-stream speed interaction region. Finally we will present a preliminary qualitative discussion of the geomagnetic response, as a function of the SW conditions generated by the ejecta near the Earth, through the analysis of key parameter (KP) data. Part of the analysis will be performed using KP data produced and archived by the central data handling facility at Goddard, with the help of the KP visualization tool developed by the ISTP/SPOF.

Aeronomical consequences of ring current energization during the early Bz less than 0 phase of the January 1997 magnetic cloud interval

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The magnetic cloud seen at Earth on January 10, 1997 was characterized by a long interval of strongly negative, followed by another long interval of strongly positive, north-south interplanetary magnetic field component (Bz). Peak negative Bz values (~ -13 nT) are reached within ~3 hours of cloud arrival, indicative of strong coupling with the magnetosphere during this early Bz negative phase [Farrugia et al., 1997]. We present a study of ring current energization during this initial period, modeling the temporal evolution of energetic H+, He+, and O+ ion species, using measurements from the CAMMICE, HYDRA, and TIMAS experiments on the POLAR spacecraft, which was on a dawn-dusk trajectory. Losses due to charge exchange, Coulomb collisions and ion precipitation are included. We focus on two issues: a) the relative contribution of the various mechanisms considered to the energy loss, and b) plasmaspheric heating during the Bz<0 phase. The possibility of SAR arc formation is addressed.

Farrugia et al., J. Geophys. Res., submitted, 1997.

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Introduction to PaPCo (Panel Plot Composer), a Common Data Analysis Tool for ISTP (International Solar Terrestrial Physics Program) and Beyond

R H W Friedel (Los Alamos National Laboratory, Los Alamos, NM) and J Faden (University of Iowa, Iowa City, IA)

PAPCO (Panel Plot Composer) is an IDL-based data analysis tool widely used by the POLAR community as a vehicle for common high resolution data analysis. PAPCO is modular in design, providing a common framework for user-written modules. PAPCO imposes little or no standards on data storage or display, allowing data from numerous sources/formats to be put together easily. Extensive documentation and templates are provided in PAPCO for the module designer. With all of the POLAR in-situ instruments being represented, and a total of over 25 modules now in existence, an investment in PAPCO offers a large return in data access-ability. In this poster we will give a basic introduction to the PAPCO system, covering the following: Distribution, Rules of the Road, Existing Modules, Functionality and Sample PAPCO output. Depending on resources we will demonstrate PAPCO on-line or on a portable PC running Windows95.

The results of this paper are the results of HYDRA NASA funding under grant number NAG 5 2231 and DARA under grant 50 OC 8911 0.

Observations of Suprathermal Plasma Sheet Electrons and Implications for Auroral Electrodynamics

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Measured electron distribution functions from the Hydra experiment on the Polar spacecraft have been fit to Maxwellian and κ distribution functions. The results from periods of time when Polar is magnetically connected to the plasma sheet suggest that these electron distributions are better parameterized by a κ distribution function than by a Maxwellian distribution function. The fits yield plasma sheet densities between 0.02 and 0.75 particles per cubic centimeter, temperatures between 500 and 2,000 electron volts, and κ's between 2 and 10. The high frequency of observations with κ less than 5 suggest that the plasma sheet often exhibits significant suprathermal behavior. The κ distribution function can often parameterize this suprathermal behavior. However, some periods of time are found to be more consistent with two temperature electron distribution functions. To illustrate the effects of suprathermal plasma sheet electrons, a two dimensional model of auroral electrodynamics has been developed by imposing current continuity in the auroral zone. In this model, the current carried by precipitating plasma sheet electrons inside auroral arcs connects to return current regions at the arc edges via ionospheric Pedersen currents. A key feature of this model implementation is the ability to parameterize the magnetospheric boundary electron population as either a κ or Maxwellian distribution. Clear differences emerge between these two distributions. The κ distribution fits predict double the peak auroral energy flux and a 20-30\% increase in the latitudinal width the auroral energy flux as compared to the Maxwellian fit results. Examples of model results and

fitted distributions will be presented.

Comparison of Solar Wind Variation and Auroral Source Electrons

- C. A. Kletzing, J. D. Scudder University of Iowa
- K. Ogilvie, R. Lepping Goddard Space Flight Center

A comparison between solar wind parameters and electron spectra measured by the Hydra particle analyzer is presented for times when Polar was in the high latitude extension of the plasma sheet at altitudes of 5-7 R_E. This region connects to the Earth's auroral zone at low altitude and is known to vary substantially over time. Understanding how the auroral source population varies with solar wind quantities improves our ability to appropriately model processes associated with substorms and auroral acceleration. Computation of moments from the electron data show that the density varies between $\sim$0.01 and $\sim$1 cm$^\{-3\}$ and that the mean energy varies between $\sim$100 and $\sim$5000 eV. Prior studies and simulation work suggest that plasma sheet energy and density are related to solar wind parameters, but initial comparisons have suggested only a weak dependence of mean energy on the B_z and E_y components of the IMF and solar wind electric field, respectively. Density is not clearly correlated with either quantity. This study extends these comparisons to include more solar wind parameters such as solar wind density and dynamic pressure. In addition, derived parameters, which have been shown to have correlation with geomagnetic indices, such as $VB_s, V^2B_s, B^2_sV,$ and ϵ, are also compared to the plasma sheet electron data. Several examples are presented along with preliminary statistics.

ULF/ELF Electric Field Signatures in the High Altitude Cusp

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Instruments on the Polar spacecraft have gathered comprehensive plasma measurements in the earth's cusps under a variety of solar wind conditions. Consistent features of these cusp encounters are intense (5-10 mV/m, rms), localized ULF/ELF electric field structures as well as distinct keV dispersed ion injections and magnetic field ULF perturbations. The DC electric field instrument (EFI) provides a detailed picture of the relationship of the broader band (0.05-20 Hz) turbulent-like wave features with the lower frequency (DC-0.05) electric fields which frequently include "spikey" waveforms. In some cases, the EFI burst memory extends the electric field frequency response to 800 Hz and also includes AC magnetic field (search coil) waveforms. By combining the low frequency electric and magnetic field data, we address the energy flow associated with the wave fields which also provides important information concerning their source region. Although the data suggest that the higher frequency waves are controlled by the lower frequency structures, the appearance of ULF waves without higher frequency spectral extensions implies that two generation mechanisms are present, or that wave damping is considerable for the higher frequencies under certain plasma conditions. The combined wave and particle observations address several aspects of high altitude wave instabilities in the cusp as well as

other, larger-scale processes.

Polar/Superdarn Boundary Mapping and Dynamics

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We present coordinated observations from satellites, HF radars and other ground-based instrumentation. These reveal that HF radar backscatter can be a useful monitor of the ionospheric footprint of the boundary between the central plasma sheet and the boundary plasma sheet. We show how this diagnostic has been used to examine the reconfiguration of the magnetotail during substorm growth phases and also in response to an IMF By change. During the substorm growth phase, it has been found that the changing latitude of the CPS/BPS boundary tracked by an HF radar is related by a simple mathematical formula to the accumulated open magnetic flux estimated from concurrent satellite measurements in the solar wind. We present a physical model that explains this quantitative relationship. The model yields an estimate for the length of the dayside reconnection X-line and places quantitative constraints on the magnetotail conditions leading up to substorm onset.

Polar cap precipitation: a coordinated POLAR-WIND Investigation.

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During its operational lifetime to date, the Hydra instrument on the Global Geospace Mission (GGS) spacecraft POLAR has made a wealth of observations on electron and ion precipitation over the polar regions of the magnetosphere near solar minimum. It typically overflies these regions 2-3 times per day, with an apogee pass over the northern polar cap lasting several hours and a much shorter (min) perigee pass over the southern polar cap. The measurements thus provided of this normally tenuous precipitation form a very important diagnostic of the state of the magnetosphere and its coupling to the solar wind. In this presentation we relate these HYDRA measurements to interplanetry conditions, which were monitored continuously by the SWE and MFI Investigations on WIND. Particular emphasis is placed on the measurements of the strahl, a closely field-aligned electron beam which carries the heat flux of the Sun and which is believed to be the source of at least the softer and structureless electron precipitation, called polar rain. A wide variety of interplanetary states are encompassed in this study. One focus of the presentation is to use extreme interplanetary conditions of long duration to test theories on the origin of the various precipitation forms (polar rain, showers and squalls) and to compare with previous results. Wherever feasible, the polar cap observations are presented in the wider context of geomagnetic activity occasioned by Earth passage of the various interplanetary configurations. We do this by emphasizing the

magnetic clouds and solar ejecta which have been selected for special study by the space physics community.

MULTI-SPACECRAFT OBSERVATIONS IN THE POLAR CUSP

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2. B T Tsurutani and C M Ho (Both at: Jet Propulsion Laboratory, Pasadena, CA 91109 USA)
3. J Chen and T A Fritz (Both at: Center for Space Physics, Boston University, Boston, MA 02215 USA)
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6. S Watanabe and H Fukunishi (Both at: Tohoku University, Sendai, JAPAN)
7. W K Peterson (Space Plasma Physics Lab, Lockheed Martin, Palo Alto, CA 94304 USA)
8. R F Pfaff, Jr. (Laboratory for Extraterrestrial Physics, NASA/Goddard Space Flight Center, Greenbelt, MD 20771 USA)
9. S Kokubun (Solar Terrestrial Environment Laboratory, Nagoya University, 3-13 Honohara, Toyokawa JAPAN)
10. I Kimura (Osaka Institute of Technology, Osaka, JAPAN)
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On September 11, 1996 at approximately 21:54 UT, a magnetic conjunction occurred between the POLAR and AKEBONO spacecraft (77 deg. invariant latitude). POLAR was in the high altitude dayside cusp (7.1 Re, 48 deg. mag. lat., 13:25 MLT) and AKEBONO was in the low altitude dayside cusp (1.3 Re, 75 deg. mag. lat., 13:27 MLT). During this time and for the ~ 10 minutes following it, both spacecraf remained in the cusp as the POLAR CAMMICE instrument observed an energetic particle event (Chen et al., J. Geophys. Res. 103, p. 69, 1998) and the POLAR VIS instrument observed the beginning and expansion of a substorm (Kp = 4+). The GEOTAIL spacecraft was in a position to monitor the solar wind at ~ 27 Re dawnward of the Earth-Sun line. Magnetosheath-like particles and waves, together with depressed and noisy magnetic field, were observed during this cusp pass at POLAR. These observations appear to be correlated with suprathermal ion measurements and consistent with other measurements made by AKEBONO. GEOTAIL observations show a noisy IMF with ~ 1-2 nT fluctuations about (-6, 8, -1) nT in GSM coordinates and a nearly steady solar wind speed of ~570 km/sec directed almost exclusively antisunward. These measurements will be discussed in terms of Earth's magnetospheric and auroral response. All of the observations will be used to draw some conclusions with respect to wave-particle interactions and to the reconnection process, which appears to be unsteady during this event.

Modeling the Mass-Dependent Plasma Entry Across the Dayside Magnetopause

T G Onsager, S A Fuselier, J D Scudder, W K Peterson, F R Toffelletto

The dayside cusp is identified by the presence of plasma of direct solar wind origin, that crosses the magnetopause and populates the open magnetic field region of the magnetosphere. Two important processes that affect the plasma properties in the cusp are the detailed magnetosheath plasma distributions, governed by processes at the bow shock and throughout the magnetosheath, and the transmission/reflection processes that occur at the magnetopause rotational discontinuity. The details of these processes are investigated here through modeling of the cusp ion and electron precipitation and the comparison with observations made by the POLAR spacecraft. The modeling is based on calculations of the transmission of realistic magnetosheath distributions across the open magnetopause and the transport of plasma in magnetospheric electric and magnetic fields. These calculaions are performed for electrons, protons, and alpha particles. The model results are then compared with POLAR measurements in the cusp under southward IMF conditions. Data from the Hydra instrument are used to investigate the electron and proton precipitation; and data from the TIMAS instrument are used to investigate the alpha particle precipitation. We find that the electron, proton and alpha particle signatures can be reasonably well represented by the model results. In addition, the ratio of alpha particle density to proton density, which varies considerably throughout the cusp, can be attributed to differences in the particle distributions in the magnetosheath and the velocity-filter effect as the entering plasma flows in the magnetospheric electric and magnetic fields.

Auroral Electrostatic Potential Drops, Ion Acceleration and Heating

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- J. M. Quinn, Space Science Center, University of New Hampshire,
- J. Wygant, School Of Physics And Astronomy, University of Minnesota,
- J.D. Scudder Department of Physics and Astronomy, The University of Iowa.

The commonly observed auroral zone phenomena of inverted V electron signatures, upflowing ion beams and plasma density depletions are widely believed to be the result of electrostatic potential drops parallel to the geomagnetic field at altitudes of several thousand kilometers. In addition to electrostatatic acceleration, details of the particle distributions also imply significant transverse heating presumably by wave-particle interactions. This heating appears quite variable in intensity and it is not clear what controls it or which mechanisms are most active.

The POLAR satellite with perigee at about 6000km over the southern polar region routinely passes through or near the region of the electrostatic potential drops and can provide insights into the acceleration and heating processes by means of simultaneous measurements of mass resolved ion distributions (TIMAS) and 3-D electron distributions (HYDRA) together with low frequency waves and plasma density (EFI).

Characteristic signatures in the electron distributions measured by HYDRA provide estimates of the strength of the electrostatic potential drop both above and below the satellite while the simultaneously measured ion distributions (TIMAS) enable tests to be made of consistency with the electrostatic potential acceleration model for ion beams and differences in the acceleration and heating between the ion species to be examined.

Are Suprathermal Populations in Space Plasmas Incidental or Essential?

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The omnipresence of suprathermal populations in accessible space plasmas is well known. The focus of this presentation is on the possible role these populations have in the scheme of plasmas? Ultimately the theoretical description of a plasma is kinetic in character. The evolution of the velocity distribution in space and time is determined by a messy non-linear partial integral equation which together with Maxwell's equations contains everthing! Because these equations are so intractable and because of the long scales lengths relative to the Debye length of the "interesting" problems of space plasmas, attempts have been made to model their behavior as a magnetized fluid(s) with finite pressure and heat flux. The well known fluid equations represent the first few velocity moments of this kinetic equation and the well known results of continuity of mass, momentum and energy result. The annoying fact that these three macroscopic equations represent only the first three of an {\it infinity} of "moment" equations to which they are attached usually escapes the cursory consideration of the three equations that have replaced the kinetic equation. This tacit truncation of the sequence of chained moment equations, followed by a closure approximation, leaves just out of sight the evolution equation for the next, fourth velocity moment or {\it Kurtosis} statistic, the first place in the moment equations where the number and distribution of particles different from a local convecting Maxwellian is tracked.

As an empirical fact the omnipresence of the suprathermals means the kurtosis of space plasma distributions is not ignorable. That the kurtosis evolves in space implies, through the usual moment equations, that the temporal and spatial evolution of the heat flux cannot be well described without addressing the physics of kurtosis evolution! Yet thermal conduction and its evolution is a central problem for the hot plasmas of astrophysics. A brief overview of two schools of thought about the origins of suprathermals and hence kurtosis will be presented. One school surmises that suprathermals arise from temporally or spatially localized happenstances occasioned by wave particle instabilities, quasi-linear plateaus, shock drift acceleration, neutral point/line acceleration or even exothermic chemical reactions such as can occur with charge exchange collisions with neutrals; however, unless the vagaries of these mechanisms are to be found to occur {\it in some time average way} at least at the source of our accessible plasmas, their observed ubiquity is not explained. The second school in which I place myself seeks an explanation for the suprathermals as a fingerprint of a plasma in the astrophysical condition: born and organized in inhomogeneous gravitational traps, governed by strong magnetic fields and the energy dependence of the Rutherford cross section, striving to remain in contact across large scales via thermal conduction - suitably generalized for the regime of astrophysics.

Reconnection Layer Geometry, Topology, Flow Characteristics and Penetration of the Diffusion Region for Northward IMF Poleward of the Cusp

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An ensemble of 18 Walen tests for anisotropic plasmas have been successfully performed during the six hour interval of May 29, 1996 when the Polar spacecraft skimmed the current carrying layer of the magnetopause during northward IMF conditions. These tests were performed while the spacecraft traversed the current carrying layer and makes use of the fact that the magnetic field is more nearly "frozen" into the electron's frame of reference than the ions. With this technique the Walen test, which is a restatement of conservation of $\matbf {E}_T$, can be pursued in thinner regions than ever before. These are the first tests of the Walen condition near the cusp for northward IMF and imply multiple traversals of locally planar rotational "discontinuities", a necessary feature of all MHD pictures of reconnection. The Walen fits are also accompanied by slope determinations that agree within 30% of the value suggested by the Walen relation (cf. Puhl-Quinn et al at this meeting). This paper demonstrates the overall spatial organization of the local normals to the current layers, the normal component of B, the inflow and exhaust Mach numbers, and the organization of the sign of the mass flux across this layer as a function of magnetic latitude. We also illustrate the topology of the magnetic separatrix using the heat flux of electrons as tracers. We demonstrate that the data are consistent with a persistant mass flux across this current layer into the magnetosphere; and, that the spatial organization of the normal component of B at these layer crossings is consistent with the idea that there was a traversal, or very near traversal of the "diffusion" region. This traversal is delineated by a normal mass flux signal that does not reverse when the normal component of B is inferred to change, a necessary condition from the Walen condition if the mass flux is to be always from the magnetosheath into the magnetosphere on {\it both} sides of the diffusion region.

The time series of these crossings are consistent with multiple crossings of the diffusion region proper, with the normal component of B being constant for 10-30sec with opposite polarities, while the field magnitude is severely depressed. There is also evidence of strong, low and high frequency electric field variations in the weak magnetic field regions of these current sheets. Variations of the electron pressure {\it anisotropy} and {\it gyrotropy} are now clearly in evidence within these current carrying layers. This is made most clear by using the highest possible time resolution magnetic field data. These test have been made at the 13.8 sec resolution of the three dimensional moments of the distribution function and the departures from gyrotropy are also seen in the distribution functions themselves with a time aliasing interval of 23msec. These signatures together with theory are strongly suggestive of the importance of the {\it full} electron pressure tensor in an adequate theory of reconnection relevant for the magnetopause (cf. also Cai and Scudder this meeting).

The following Invited Paper will be presented at the 1998 Spring American Geophysical Union (AGU) Meeting to be held in Boston, Massachusetts, May 26-29, 1998, in the SM01 special session on ISTP/IACG Event and Campaign Correlative Analysis

Examining Indications From POLAR and GEOTAIL That Auroral Kilometric Radiation Can Trigger the Aurora

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4. M Walt, STAR Laboratory, Stanford University, Stanford, CA 94305
5. G Rostoker, Department of Physics, University of Alberta, Edmonton, Alberta, Canada T6G 2J1
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7. D H Fairfield, NASA/Goddard Space Flight Center, Greenbelt, MD 20771

Several events have been detected in which strong burst of AKR near the local electron cyclotron frequency preceded the detection of strong bursts of 2-12 keV X-Rays from precipitating electrons by several tens of seconds. During southern hemisphere perigee passes in early 1997 of the NASA POLAR satellite, Auroral Kilometric Radiation (AKR) and precipitating electrons were measured remotely by the POLAR Plasma Wave Instrument (PWI) and X-Ray Imager (PIXIE), respectively. GEOTAIL, when near its apogee at -30 Re in the tail, detected enhancements in AKR at the same time as the POLAR AKR observations began. At nearly the same time the CANOPUS ground magnetometers, usually when located near local night, indicated the beginning of a geomagnetic disturbance. The strong X-Ray bursts which followed several tens of seconds later occurred simultaneously with the observation by POLAR of enhanced low frequency electrostatic noise. The POLAR HYDRA experiment detected inverted Vs centered on the peak of the precipitating electrons. On several occasions strong bursts of up-going ions were also observed. For some of the events, GEOTAIL detected in situ changes in the magnetic field indicating motion of the spacecraft in the plasmasheet towards the current sheet before the strong AKR and X-Ray bursts followed by movement away afterwards. Occasionally a plasmoid or flux rope was detected tens of minutes after the event. Some events were very brief. If triggering of the aurora by AKR occurs, it is evident that the magnetosphere has to be ready to respond in order for significant activity to continue. It is possible that the AKR might initially be produced by precipitating electrons that produce X-Rays below the PIXIE detectable range. We will discuss the plausible explanations for these many interesting observations.

Non-Gyrotropic Electron Pressure in Collisionless Magnetic Reconnection

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   Tel: 319-335-1683; Fax: 319-335-1753
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When the interplanetary magnetic field is northward, the Hydra plasma analyzer on the Polar spacecraft may pass through the magnetic reconnection diffusion region. This provides a good opportunity to compare particle simulation results with measurements in collisionless environment. We have carried out a two-dimensional full particle simulation in which a guiding magnetic field is included, and shown that the off-diagonal elements of electron and ion pressure tensors play a dominant role in providing a balance to the reconnection electric field near an X line. The simulation electron pressure tensor is found to be not only anisotropic but also non-gyrotropic, and the major axis associated with the most parallel

pressure eigenvalue can significantly deviate from the local magnetic field direction. The non-gyrotropic electron pressure tensor is a result of dispersive (energy dependent and spatially sensitive) motions of electrons with finite gyroradii near the X line. The projection of the electron distribution in the $v_\parallel - v_\perp$ space is D-shaped. Hydra measurements indeed show evidence of non-gyrotropic electron distribution when the Polar spacecraft passes through the reconnection diffusion region.

Are CEP's the High-energy Extension of Hydra Spectrum?

1. S.-W. Chang and J. D. Scudder (Dept. of Physics and Astronomy, The University of Iowa, Iowa City, IA 52242; ph. 319-335-3828; swc@hydra.physics.uiowa.edu)
2. H. E. Spence (Boston University, Dept. of Astronomy and Space Physics, 725 Commonwealth Ave.,Boston, MA 02215)

Recent interpretations [Chen et al., 1997; 1998] of energetic ions (10-100 keV) by the Polar spacecraft have suggested a new energization process to be at work in the polar cusp. In this work, we examine the ion energy spectrum from 1 to a few 100 keV detected by the Hydra, CAMMICE, and CEPPAD instruments onboard Polar and investigate the hypothesis that these particles are of solar wind origin. Preliminary results suggest that the energy spectrum is continuous from 1 keV well up into the low solid state energies (10-100 keV) of the CAMMICE instrument where these events were originally identified. The observed cusp ion distributions reveal thermal and suprathermal components. It is well known that 10-20% of solar wind ions are reflected and energized at supercritical, quasi-perpendicular bow shocks. As these particles drift along the shock surface electric field they gain energy, eventually penetrate the shock layer, and form a suprathermal tail in the magnetosheath velocity distribution function. These particles together with the directly transmitted solar wind particles would follow magnetic field lines entering the magnetosphere through the cusp. A possible competing second energization process occurs at the magnetopause current layer. According to Cowley's and others' studies, ions may gain or lose energy in this process as well. We will assess the relative importance of the Cowley and bow shock drift acceleration mechanisms as an explanation for the occurrence of these two populations found in the cusp.

Results from Hydra

PRESENTATIONS:

FALL 1996 AGU MEETING

Latitudinal Profiles of Ring Current Ions During Moderate Geomagnetic Activity
VK Jordanova, JM Quinn, CJ Farrugia, L Janoo, JE Borovsky, RB Sheldon, EG Shelley

Comparison of Auroral X-ray Emissions with Simultaneously Measured Energetic Electron Precipitation
PC Anderson, D Chenette, DL McKenzie, JM Quinn, M Grande

Polar Hydra Particle Data -- Comparisons with Auroral Sounding Rocket Observations
KA Lynch, RL Arnoldy, RB Torbert, CA Kletzing, JD Scudder, PM Kintner

Magnetic Field and Plasma Observations made by Wind on May 27-30, 1996: Triggers of Magnetospheric Activity
LF Burlaga, CJ Farrugia, LP Lepping , KW Ogilvie, JM Quinn, RB Torbert, L Janoo, JD Scudder, AJ Lazarus, JT Steinberg

1997 PAROS SYMPOSIUM ON SOLAR-TERRESTRIAL COUPLING

Transverse and Parallel Auroral Ion Acceleration as Observed from the Polar Satellite
EG Shelley, VE Angelopoulos, HL Collin, WK Peterson, JM Quinn, JD Scudder, JR Wygant

SPRING 1997 AGU

Plasma Convection/Injection as Observed from the POLAR spacecraft
JM Quinn, VK Jordanova, JD Scudder, HL Collin, EG Shelley

Separatrix Crossings and Possible Penetration of the Diffusion Region inan Example of Reconnection, Poleward of the Cusp
JD Scudder, JC Dorelli, CA Kletzing, RD Holdaway, P Quinn, JB Faden, HJ Cai, KW Ogilivie, CJ Farrugia, CT Russell

Upflowing Ions and Auroral Plasma Density Depletions
HL Collin, WK Peterson, EG Shelley, J Wygant, JM Quinn, F Mozer, JD Scudder

A Study of Ring Current Activity During Passage of the January 1997 Magnetic Cloud
VK Jordanova, CJ Farrugia, JM Quinn, LF Burlaga, KW Ogilvie, RP Lepping, G Lu, AJ Lazarus, RD Belian, MF Thomsen

Ion Acceleration in the Auroral Zone: From Sounding Rockets to Polar
K Lynch, R Arnoldy, P Kintner, J Franz, J Bonnell, J Scudder, C Russell

FALL 1997 AGU

Observations of polar cap electron modulation under a wide variety of interplanetary conditions
JM Quinn, CJ Farrugia, L Janoo, JD Scudder, KW Ogilvie, RJ Fitzenreiter, RP Lepping, AJ Lazarus, JT Steinberg

Aeronomical Consequences of Ring Current Energization During the Early BZ<0 Phase of the January 1997 Magnetic Cloud Interval
VK Jordanova, CJ Farrugia, HL Collin, JL Roeder, JU Kozyra, RM Thorne

1998 IPELS

Auroral Particle Acceleration and Electric Currents
K Lynch, R Arnoldy, R Torbert, P Kintner, J Bonnell, Primdahl, J Scudder, C Russell

SPRING 1998 AGU - INVITED

Electron Precipitation in the Polar Cap: POLAR Observations
CJ Farrugia, JM Quinn, JD Scudder, X Cao, KW Ogilvie, RJ Fitzenreiter

Ring Current Modeling Using Multiple Spacecraft Data
VK Jordanova

SPRING 1998 AGU - CONTRIBUTIONS

Auroral Electrostatic Potential Drops, Ion Acceleration and Heating
H.L. Collin, E.G. Shelley, J.M. Quinn, J. Wygant, J.D. Scudder

PUBLICATIONS

In Preparation:

Simulation of latitudinal profiles of ring current ions measured by POLAR for a moderate storm at solar minimum
VK Jordanova, CJ Farrugia, JM Quinn, JE Borovsky, RB Seldon, and EG Shelley

SUBMITTED

Unusual features of the January 1997 magnetic cloud and the effect on optical dayside auroral signatures

CJ Farrugia, PE Sandholt, J Moen, RL Arnoldy
Submitted Geophys. Res. Lett.

Comparison of Auroral X-ray Emissions with Simultaneously Measured Energetic Electron Precipitation
PC Anderson, DL Chenette, DL McKenzie, JM Quinn, M Grande, M Carter.
Submitted Geophys. Res. Lett.

ACCEPTED

Effect of Wave-Particle interactions on Ring Current Evolution for January 10-11, 1997: Initial Results
VK Jordanova, CJ Farrugia, JM Quinn, RM Thorne, KW Ogilvie, RP Lepping, G Lu, AJ Lazarus, MF Thomsen, RD Belian.
In press, 1998, Geophys. Res. Lett.

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Brenda L. Akins
Acting for
David J. Skorton

David J. Skorton
Vice President for Research

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Date

Title: Methodology for 3D Quadrature of GGS/HYDRA Data Including Calibration Data, Spacecraft Potential Variations and Photoelectron Contamination

Project Director: Jack D. Scudder

Agency: NASA/Goddard Space Flight Center

Date: March 24, 1998

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